
Healing of apical periodontitis after endodontic treatment: a comparison between a silicone-based and a zinc oxide–eugenol-based sealer

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Abstract

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Aim To assess the treatment results up to 1 year after endodontic treatment of apical periodontitis using a silicone-based sealer in comparison with Grossman's sealer, and to compare the results at 3 months after treatment with the 12-month follow-up to assess the prognostic value of a 3-month control.

Methodology A total of 199 teeth were treated at three centres. The sealer was randomly chosen at the time of filling. Treatment results were evaluated

clinically and radiographically 3 and 12 months after root-canal filling. The periapical status was evaluated using the periapical index (PAI).

Results and conclusions Average PAI scores decreased from 3.43 at start to 2.21 at 12 months for Grossman's sealer and from 3.40 to 2.26 for the silicone-based material. No significant difference between the groups at start or any of the follow ups was seen. The 3-month control was adequate in establishing significant healing in both groups. The improvement of the periapical condition continued at the 12-month examination.

Keywords: apical periodontitis, root-canal sealer, silicone, ZOE.

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Introduction

Bacteria in dental root canals play a decisive role in the development of chronic apical periodontitis, and their elimination is the ultimate aim of endodontic treatment of infected teeth. The role of the root filling is to serve as a protection after biomechanical root-canal preparation by preventing bacterial ingress and activity and allowing the regenerative processes in the periapical tissues to proceed without harming them. Different methods and materials have been proposed for root-canal obturation. Most make use of gutta-percha cones in conjunction with a sealer. A sealer is required, because gutta-percha adheres poorly to root dentine and will not effectively seal off the root-canal system. Several types of sealers have been used with different physical

and biological properties. Ideally, the root-canal sealer should be biocompatible and have satisfactory physical–chemical properties. Currently, root-canal sealers are available based on various formulas such as epoxy resin, calcium hydroxide and zinc oxide–eugenol (ZOE). The choice of sealer, however, may have an influence on the results of endodontic therapy (Ørstavik *et al.* 1987, Waltimo *et al.* 2001).

Silicone is inert and biocompatible and has been widely used in medicine as an implant material (Habal 1984, Deva *et al.* 1998). Silicone-based root-canal sealers are also available. However, there are no data on the clinical performance of this type of material in endodontic treatment.

The main purpose of this multicentre, prospective clinical study was to assess the treatment results up to 1 year after endodontic treatment of apical periodontitis using a silicone-based sealer (Roeko Seal Automix, Roeko, Langenau, Germany) in comparison with a ZOE-based, Grossman's type sealer. Moreover, the results

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at 3 months after treatment were compared with the 12-month follow-up to assess the prognostic value of a 3-month control.

Materials and methods

A total of 199 teeth were treated. Roeko Seal Automix (RS) was used according to manufacturer's directions; and Grossman's sealer (GS) was mixed according to Grossman (1978) (Table 1). Treatment was conducted by senior dental students, graduate students or clinic staff at the University of North Carolina at Chapel Hill, USA; University of Turku, Finland; or by endodontists in private practice in Oslo, Norway.

Patients

The study was approved by the Ethics Committees in Finland, Norway and the US, and the subjects gave written informed consent. The primary criterion for inclusion of subjects in the study was the presence of radiographically discernible apical periodontitis on a single-rooted tooth or on one root with a single canal in one root of a multirrooted tooth. Patients were excluded if (a) they had diagnosis of diabetes, (b) they had diagnosis of HIV infection, or other immunocompromising disease, (c) they were <20 or >80 years old.

Clinical and dental variables

For each tooth, the following information was recorded at every examination: tooth type, soft tissue status, subjective pain, sensitivity to percussion and mobility, caries, restoration, dental arch support, antagonist, and occlusal interference.

Endodontic treatment

The method of instrumentation was at the discretion of the operator or clinic, but with minimum ISO 35 for

Table 1 Formula of the Grossman's root-canal sealer (from Grossman 1978)

Powder	
Reagent grade ZnO	42
Hydrogenated rosin	27
Bismuth subcarbonate	15
Barium sulphate	15
Anhydrous sodium borate	1
Liquid	
Eugenol	100

Values are in percentage.

apical instrumentation. Calcium hydroxide was used as an interim dressing for a minimum of 7 days. When the root was ready for filling, the sealer was chosen by the flipping of a coin. A standardized gutta-percha master point was used with a sealer, and cold lateral condensation of accessory points completed the root filling of each root. The root filling was characterized with regard to the type of sealer, and the quality and extension of the root filling as assessed radiographically. The patients participated in a 3- and 12-month recall programme of clinical/radiological examination.

Radiographic technique and scoring

Radiographs were taken with individual bite-blocks attached to beam-guiding device. The exposed films were processed in an automatic processor.

For each tooth the level of marginal bone, density and length of root-canal filling and periapical status were recorded. The periapical status was assessed by means of the periapical index (PAI) scoring system, as described previously (Ørstavik *et al.* 1986) (Table 2). 'Improvement' was calculated as a case showing lower PAI score at 3 or 12 months than at root filling. PAI scores were also pooled to 'success' (PAI 1 and 2) at 12 months. The scores were used for quantitative analyses of the treatment results.

One investigator (S.H.) analysed all the radiographs. Before scoring PAI, the investigator was calibrated by twice scoring a standard set of 100 cases of individual radiographs. After scoring the reference teeth, the scores were compared to the authoritative scores, and a Cohen's $\kappa = 0.7$ was obtained, indicating good reproducibility.

Statistical analysis

The sealer was considered the dependent variable of the study. The other clinical and radiographical variables of known or possible influence on treatment prognosis were recorded for description of the material.

As PAI scores are noncontinuous data, nonparametric tests were used for the analyses. The Mann-Whitney *U*-test was used to compare sealer groups at different

Table 2 Basic elements of the PAI scoring system (Ørstavik *et al.* 1986)

1	Normal periapical structures
2	Small changes in bone structure
3	Changes in bone structure with some mineral loss
4	Periodontitis with well-defined radiolucent area
5	Severe periodontitis with exacerbating features

time points. For analysis of the process of healing between different time points, the Friedman's test was used to determine whether an overall difference existed. If a difference was found, the Wilcoxon's test was used for paired comparisons. A level of $\alpha = 0.01$ was chosen for statistical significance.

Results

Of the 199 teeth, 156 could be followed for 12 months (Table 3). There was no difference in dropouts between the sealer groups (Table 3). Patients in RS group were slightly younger (Table 4). No differences in gender (Table 4) or tooth type (Table 5) between sealer groups were seen. At the outset or any other examination, there were no significant differences between sealer groups in any of the clinical or dental variables studied. Marginal bone level, density and length of filling or surplus did not differ between sealer groups (Table 6). The PAI values in the RS and GS groups at start were similar (Fig. 1). It

Table 3 Number of teeth in different sealer groups

Time	RS		GS	
	No.	%	No.	%
Start	105	100	94	100
Filling	103	98	94	100
12 weeks	93	89	81	86
12 months	84	80	72	77

Table 4 Sex and age of patients

	RS	GS
Total number of patients	105	94
Sex		
Females	54	50
Males	51	43
Missing	0	1
Age (years)		
20–39	18	21
40–59	49	27
60–79	35	42
>79	1	1
Missing	2	3

Table 5 Tooth types at start

	Maxilla		Mandible	
	RS	GS	RS	GS
Incisors	18 (17.1)	11 (11.7)	3 (2.9)	4 (4.3)
Canines	9 (8.6)	6 (6.4)	1 (1)	2 (2.1)
Premolars	21 (20)	23 (24.5)	21 (20)	15 (16)
Molars	16 (15.2)	15 (16)	16 (15.2)	18 (19)

Values in parentheses are in percentage.

Table 6 Radiographic variables and frequency

	RS	GS
Marginal bone		
>2/3 root support	94 (91.3)	85 (90.5)
1/2–2/3 root support	6 (5.8)	7 (7.4)
<1/3 root support	1 (1.0)	2 (2.1)
Not scored	2 (1.9)	
Root filling density		
Well-condensed apical 1/3	99 (96.1)	93 (98.9)
Slits along root filling apical 1/3	4 (3.9)	1 (1.1)
Root filling length		
<2 mm to apex	75 (73.3)	72 (76.6)
3–4 mm to apex	7 (6.7)	3 (3.2)
Surplus <1 mm	13 (12.4)	17 (18.1)
Surplus >1 mm	8 (7.6)	2 (2.1)

Values in parentheses are in percentage.

was a general observation that periapically extruded sealer was not absorbed by the tissues during the observation period.

Any subjective pain had been eliminated at the time of filling. Soft tissue and percussion status improved considerably between start and filling, and continued to improve at follow-ups. Figure 2 shows the percentage of cases at different time points showing healing of apical periodontitis. The healing was seen as a decrease in PAI scores at 12 weeks. This difference was statistically significant. Also a significant decrease was found between 12- and 52-week control. The overall 'success' rate at 12 months was 76%. 'Improvement' was 47 and 78% at 3 and 12 months, respectively.

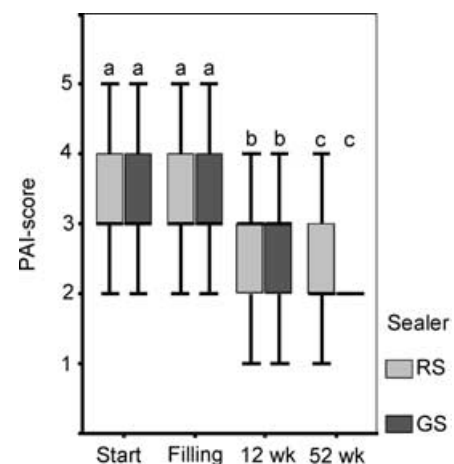


Figure 1 The effect of the sealer used on changes in periapical status (the boxes show the first and third quartiles with the median value in bold line. The whiskers show the minimum and maximum). Identical letters indicate no statistically significant differences ($\alpha = 0.01$).

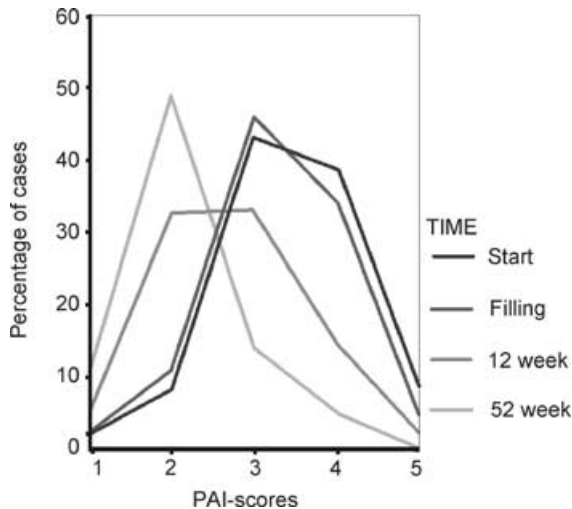


Figure 2 Distribution of teeth in PAI scoring categories at various time points showing progression of healing of apical periodontitis.

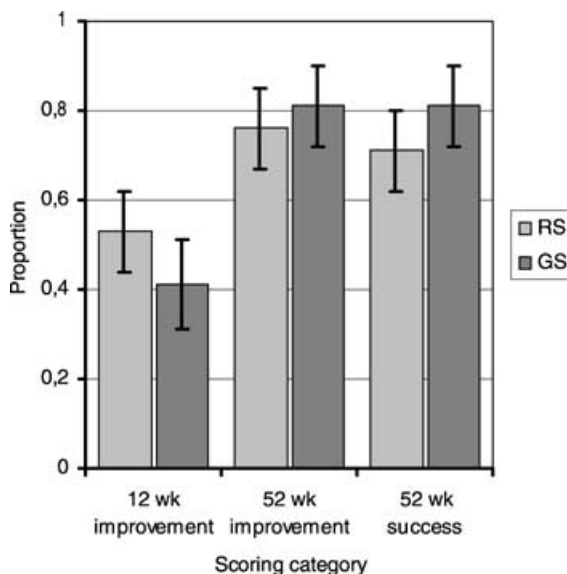


Figure 3 Improvement at 3 and 12 months and 'success' at 12 months in RS and GS groups (bars represent proportion; error bars represent confidence intervals for proportions).

Average PAI scores decreased from 3.43 at start to 2.21 at 12 months for GS and from 3.40 to 2.26 for RS. In both sealer groups there was a statistical significant decrease of PAI scores after root-canal filling at 3 and 12 months examinations compared to time of filling (Fig. 1). No significant difference between the groups at start or any of

the follow ups was seen. Overfilled teeth in either group did not differ from others in respect of healing. There was no statistically significant difference in healing after treatment with RS compared to GS, expressed as either 'success rate' or 'improvement' (Fig. 3).

Discussion

Patients in this multicentre study were selected on the basis of radiographically discernible apical periodontitis. Initially, there were 199 teeth, with a total of 84 teeth filled with RS and 72 teeth filled with GS which were followed for the whole 12-month period. The proportion of dropouts was approximately the same in both sealer groups. The recall rate of 78% compared well with previous prospective studies (Kerekes & Tronstad 1979, Friedman *et al.* 1995).

Radiographic estimation of periapical structures is a complex task. Several criteria and different combinations of radiographic features have been developed to discriminate between healthy and diseased state (Ödesjö *et al.* 1990, Heling *et al.* 2001). In many studies, the success–failure analysis (Strindberg 1956) has been used to determine the outcome of endodontic treatment or to evaluate the periapical status in epidemiological studies. Another method to analyse periapical structures in follow-up (Ørstavik & Hørsted-Bindslev 1993, Trope *et al.* 1999, Waltimo *et al.* 2001) or epidemiological studies (Kirkevang *et al.* 2001, Boucher *et al.* 2002) is the PAI. It is based on Brynolf's (1967) comparative histopathological-radiographic studies. The reliability has also been tested using densitometric measurements (Delano *et al.* 2001). In our study, the PAI scores were also used to calculate measures of the success rate and improvement, to document the results after 12 months of follow up.

Healing of apical periodontitis as seen on radiographs may begin shortly after endodontic treatment, in some cases as early as 1 week (Kerosuo & Ørstavik 1997). Byström *et al.* (1987) suggested that as long as there is a continuous decrease in the size of lesion, there is no reason to judge a case a failure. There may be several reasons for apical periodontitis to heal at different rates or not to heal. The endodontic treatment may not have eliminated all the bacteria from the root canal, in exposed dentinal tubules, in lacunae of cellular cementum or in apical foramina. Another reason may be that infected dentine and cementum chips are forced into the periapical tissue during mechanical instrumentation (Yusuf 1982). Sometimes, the reduction of lesion size continues for 4–5 years (Byström *et al.* 1987) or even 8–9 years

(Strindberg 1956). From a clinical point of view it may be of interest to predict the prognosis of a tooth as early as possible after treatment. The estimation of different radiographic signs and clinical risk factors or a combination of them is a subject of future studies.

In this study, the healing of apical periodontitis related to two different root-canal sealers under similar conditions was compared. The periapical condition at the beginning was similar in both groups (Fig. 1). The process of healing, i.e. the change of PAI scores, was clearly seen at 12 weeks of follow up and it continued over the whole follow-up period indicating that the dynamics of healing was similar in both sealer groups. Thus, the healing pattern seems largely unrelated to the sealer used, in accordance with previous studies using other sealers (Ørstavik 1996, Waltimo *et al.* 2001).

The prognosis of endodontic therapy has been shown to be poorer when the root-canal filling is overextended (Bergenholtz *et al.* 1979, Swartz *et al.* 1983) or underextended (Sjögren *et al.* 1990). Nevertheless, in many cases sealer or gutta-percha have been extruded into the periapical tissues and left for years in well-obtured root canals without clinical or radiographic evidence of failure (Weine 1996). In our study, the results did not differ between different filling lengths. If the filling was overextended, it was not resorbed during the follow-up period. Unlike many sealers, extruded RS does not seem to be absorbed, and it probably becomes an 'implant' in the periapical area. The adverse effects of root filling excess may be due to overinstrumentation, which normally precedes overfilling. This may force infected dentine chips into the periapical tissue (Yusuf 1982). Periapical granulomas from cases of failed endodontic treatment often contain foreign material such as dentine and cementum chips and/or root-canal filling material.

It is generally agreed (Sundqvist & Fidgor 1998) that the permanent root filling should be an inert, physical barrier to ingress of bacteria or toxins. However, conventional sealers all exhibit some biological and antimicrobial activity. The fact that the relatively inert, silicone-based RS sealer performed as well as the conventional GS, testifies to the validity of the supposition that the antimicrobial part of treatment is completed prior to the placement of the root filling.

Conclusion

In conclusion, the treatment outcome after root filling with either Roeko Seal Automix or Grossman's sealer 1 year after treatment of apical periodontitis was similar. The process of healing could be statistically

verified for each group as early as 12 weeks after root-canal filling.

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